Faculty of Electrical Engineering

AN ENVIRONMENTALLY ENERGY DISPATCH USING NEW META HEURISTIC EVOLUTIONARY PROGRAMMING

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Master of Science in Electrical Engineering

2018

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A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
in Electrical Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled "An Environmentally Energy Dispatch using New Meta Heuristic Evolutionary Programming" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Master of Science in Electrical Engineering.

Signature	:	……………………………..
Name	:	Dr. Elia Erwani binti Hassan
Date	:	……………………………..

DEDICATION

A million praise towards my family, my beloved wife, my respectful supervisor, examiner and lecturers and to all my friends for their support and cooperation in helping me to complete this thesis.

Thanks to the Ministry of Higher Education (MOHE) for provide Short Grant namely RAGS/1/2015/TK0/FKE/03/B0094 under Universiti Teknikal Malaysia Melaka (UTeM) for the financial support for my study.

Your supports are highly appreciated and very meaningful to me.

ABSTRACT

Basically, one important issue in the power system network is to provide the optimal Economic Load Dispatch (ELD) solution in order to guarantee the sustainable consumer load demand. However, today ELD solution is essential to include together with the environmental aspect and known as Environmental Economic Load Dispatch (EELD). For that reason, many researchers continue in the development of new simulation tool specifically to overcome the EELD problems. Therefore, this study prepared an improved hybrid metaheuristic technique named as New Meta Heuristic Evolutionary Programming (NMEP) to provide the best possible solution in solving the identified single objective and multi objective functions for EELD solution. This new technique a merging cloning strategy that involved in an Artificial Immune System (AIS) algorithm into algorithm of Meta Heuristic Evolutionary Programming (Meta-EP). The development of NMEP technique is to minimize total cost, reduce the total emission during generator operation through the common formula in EELD and lowest total system loss. Besides that, all mentioned objective functions were also optimized together simultaneously that formulated using the weighted sum method before had been executed on the multi objective NMEP or called MONMEP. Both individual and multi objective NMEP techniques performance were verified among other two common heuristic methods known as AIS and Meta-EP techniques. In addition, the best possible solution defined using the aggregate function method. Through this method, the selection of the best MOEELD solution became effortless as compared with MO individually that required compare two or more objective function in one time manually. Among those three optimization techniques the lowest total aggregate values mostly resulted via the NMEP technique. Based upon that, the proposed technique is proving as the outstanding method compared with Meta-EP and AIS techniques in solving the EELD problem for both standard IEEE 26 bus and 57 bus systems.

ABSTRAK

Pada dasarnya, satu isu penting dalam rangkaian sistem kuasa adalah untuk menyediakan penyelesaian Penghantaran Beban Ekonomi (ELD) yang optimum untuk menjamin permintaan beban pengguna yang sesuai. Walau bagaimanapun, penyelesaian ELD hari ini adalah penting disertakan bersama dengan aspek alam sekitar dan dikenali sebagai Penghantaran Beban Ekonomi Alam Sekitar (EELD). Atas sebab itu, banyak penyelidik meneruskan pembangunan alat simulasi baru yang khusus untuk mengatasi masalah EELD. Oleh itu, kajian ini menyediakan teknik metaheuristik hibrid yang lebih baik dinamakan sebagai Pengaturcaraan Meta Heuristik Evolusi Baru (NMEP) untuk memberikan penyelesaian yang terbaik dalam menyelesaikan fungsi objektif tunggal dan objektif pelbagai bagi masalah EELD. Teknik baru ini menggabungkan strategi pengklonan yang terlibat dalam algoritma Sistem Imunisasi Buatan (AIS) ke dalam algoritma Pengaturcaraan Meta Heuristik Evolusi (Meta-EP). Pembangunan teknik NMEP adalah bagi mengurangkan kos keseluruhan, mengurangkan jumlah pelepasan semasa operasi penjana melalui formula umum dalam EELD dan jumlah kerugian sistem terendah. Di samping itu, semua fungsi objektif yang disebut juga dioptimumkan bersama-sama secara serentak yang dirumuskan menggunakan kaedah jumlah tertimbang sebelum dilaksanakan pada NMEP objektif pelbagai atau dipanggil MONMEP. Kedua-dua prestasi teknik NMEP objektif individu dan pelbagai disahkan dalam kalangan dua kaedah heuristik yang biasa dikenali sebagai teknik AIS dan Meta-EP. Di samping itu, penyelesaian yang terbaik akan ditakrifkan menggunakan kaedah fungsi agregat. Melalui kaedah ini, pemilihan penyelesaian MOEELD yang terbaik menjadi lebih mudah berbanding dengan MO secara individu yang memerlukan perbandingan dua atau lebih fungsi objektif dalam satu-satu masa secara manual. Antara ketiga teknik pengoptimuman ini, jumlah nilai agregat paling rendah kebanyakannya dihasilkan menerusi teknik NMEP. Berdasarkan itu, teknik yang dicadangkan terbukti menghasilkan kaedah yang cemerlang berbanding dengan teknik Meta-EP dan AIS dalam menyelesaikan masalah EELD bagi kedua-dua standard IEEE 26 bus dan 57 sistem bas.

ACKNOWLEDGEMENTS

First of all, Alhamdulillah thanks to Allah Almighty because of His blessing I would able to finish out my research. In preparing this thesis, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thought. In particular, I wish to express my sincere appreciation to my supervisor, Dr. Elia Erwani binti Hassan for her supports, trust, guidance critics, encouragement and advices throughout this research.

Then, a million thanks towards my co-supervisor Prof. Madya Dr. Abdul Rahim bin Abdullah for his guidance, advices and motivation. Without their continued support and interest, this research would not have been same as presented here. I am also indebted to Universiti Teknikal Malaysia Melaka research grant RAGS/1/2015/TK0/FKE/03/B0094 and Ministry of Higher Education (MOHE) for their funding. Next, I also want to thank my parents and my dearest wife Fatin Liyana binti Jamaludin for their endless support, spirit, motivation and advices for continuing my studies. Behind that entire process, they also have contributed, financially.

Last but not least, my fellow postgraduate students from Advanced Digital Signal Processing (ADSP) laboratory should also be recognized for their support and cooperation in completing this thesis. Finally, my sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members. Thank you very much.

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LIST OF ABBREVIATIONS

ACO	-	Ant Colony Optimization
ADSP Lab	-	Advanced Digital Signal Processing Laboratory
AI	-	Artificial Intelligence
AIS	-	Artificial Immune System
ED	-	Economic Dispatch
EELD	-	Environmental Economic Load Dispatch
EP	-	Evolutionary Programming
GA	-	Genetic Algorithm
IEEE	-	Institute of Electrical and Electronics Engineers
LP	-	Linear Programming
Meta-EP	-	Meta Heuristic Evolutionary Programming
MINLP	-	Mix Integer Non Linear Programming
MOAIS	-	Multi Objective of Artificial Immune System in Fixed Weight
MOCEEELD	-	Multi Objective for Total Generation Cost and Total Emission of Environmental Economic Load Dispatch
MOCELEELD	-	Multi Objective for Total Generation Cost, Total Emission and Total System Loss of Environmental Economic Load Dispatch
MOCLEELD	-	Multi Objective for Total Generation Cost and Total System Loss of Environmental Economic Load Dispatch
MOEELD	-	Multi Objective of Environmental Economic Load Dispatch

MOELEELD	-	Multi Objective for Total Emission and Total System Loss of Environmental Economic Load Dispatch
MOMeta-EP	-	Multi Objective of Meta Heuristic Evolutionary Programming in Fixed Weight
MONMEP	-	Multi Objective of New Meta Heuristic Evolutionary Programming Method Optimization
NLP	-	Non Linear Programming
NMEP	-	New Meta Heuristic Evolutionary Programming Optimization
OPF	-	Optimal Power Flow
PSO	-	Particle Swarm Optimization
SA	-	Simulated Annealing
SOCEELD	-	Single Objective for Total Generation Cost of Environmental Economic Load Dispatch
SOEEELD	-	Single Objective for Total Emission of Environmental Economic Load Dispatch
SOEELD	-	Single Objective of Environmental Economic Load Dispatch
SOLEELD	-	Single Objective for Total System Loss of Environmental Economic Load Dispatch
TS	-	Tabu Search

LIST OF SYMBOLS

$C_i(Pg_i)$	Cost of generation for unit *i*
Pg_i	Power generated by unit *i*
$a_i,\ b_i,\ c_i$	Cost coefficient for unit *i*
C_{Total}	Total cost of generation
N_g	Number of generator units
P_{gi}	Power generated by unit *i*
α_i , β_i , γ_i , εi, λ_i	Emission coefficient of *i* th generator
P_i	Power generated by unit *i*
P_{min}	Minimum real power generated by unit *i*
P_{max}	Maximum real power generated by unit *i*
V_{min}	Minimum voltage at load buses
V_{max}	Maximum voltage at load buses
k	Numbers of objective function.
α_i	Weighting factor for i^{th} objective function
f_{ni}	Normalised value for i^{th} objective function
T_{loss}	The sum of losses
P_{load}	The real power load demand
L_i, L_{oi}, $\eta_{i,j}$ *and* $\eta'_{i,j}$	The i^{th} components of the respective vectors

LIST OF PUBLICATIONS

A. Journal

1) **Ridzuan, M.R.M.**, Hassan, E.E., Abdullah, A.R., Bahaman, N. and Kadir, A.F.A., 2018. The Multi Objective Environmental Load Dispatch Hybrid Optimization Solution. *Journal of Fundamental and Applied Sciences*, *10(5S)*, pp.243-257.

2) **Ridzuan, M.R.M.**, Hassan, E.E., Abdullah, A.R., Bahaman, N. and Kadir, A.F.A., 2018. Sustainable Environmental Economic Dispatch Optimization with Hybrid Metaheuristic Modification. *Indonesian Journal of Electrical Engineering and Computer Science*, *11*(1).

3) **Ridzuan, M.R.M.**, Hassan, E.E., Abdullah, A.R., Bahaman, N. and Kadir, A.F.A., 2017. NMEP based Gaussian Mutation Process on Optimizing Fitness Function for MOEED. *International Journal on Advanced Science, Engineering and Information Technology, 7(5),* pp.1840-1846.

4) **Ridzuan, M.R.M.,** Hassan, E.E. and Abdullah, A.R., 2016. A Hybrid MEP and AIS Algorithm for Energy Dispatch in Power System. *International Journal of Simulation Systems, Science & Technology*, 17(41).

5) **Ridzuan, M.R.M.,** Hassan, E.E., Abdullah, A.R., Bahaman, N. and Kadir, A.F.A., 2016. A New Meta Heuristic Evolutionary Programming (NMEP) in Optimizing Economic Energy Dispatch. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, *8*(2), pp.35-40.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Power system optimization which strongly related to economic dispatch is aiming for better solution so that the smooth and secured load demand will be supplied to consumers (Chowdhury et al., 1990). Initially, the common problem in the power system is the load demand increased without much attention about the security aspect in the power system-network. Most problems came from highly nonlinear, non-convex, non-smooth and dynamic economic load dispatch problem through the objective function along with equality and inequality constraints (Kamboj et al., 2017, Shahinzadeh et al., 2017 and Nag, 2017). Hence, the modern simulation mechanism is needed to optimize the economic load dispatch in the power system network at any possibility conditions as the best suitable solution especially to overcome the Environmental Economic Load Dispatch (EELD) problems.

Mainly, the objective of the EELD in a power system is to minimize the total cost of generating units and total losses during the operation. Initially, the clean air act of 1990 emphasized that more power generated through the generation will produce a lot of polluted gaseous like a Sulfur Dioxide (SO_2), Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) emission level spread to the environment (Boroojeni et al., 2017 & Mohammadi et al., 2017). As a result, the objective functions in generating load demand of power system no longer considered the entire cost alone but also include with the emission quantities and losses as well.

Previously, many researches introduced the mathematical solutions to solve the EELD problems. However, a lot of issues were formed a non-linear and complicated objective functions problem thus required for more robust and efficient simulation tool for the finest possible result. In addition, the mathematical solutions associated with some constraints parameters to provide a secured nonlinear objective functions solutions. Therefore, several related mathematical or classical techniques which solved the EELD were also explained in this thesis to fulfil the gap during their implementation.

As that fact, this study introduced a new technique as an alternative method aims to overcome the singular and multi-objective functions identified in the EELD problems successfully (Zhang et al., 2017). The technique named as New Meta Heuristic Evolutionary Programming (NMEP) technique fundamentally is developed from the modification of the basic Meta-EP algorithm with the cloning process organization in the AIS strategies. Begin with the mutation process along with the cloning process generate numerous of population value that create the special ability for NMEP to choosing a better selection of populations in order provide the best performance solving EELD problem in power system. In consequence the NMEP dissolved the most the problem occur on the EELD i.e. highly nonlinear, non-convex, non-smooth during the simulation.

As we known, the selection of suitable objective functions is essential to guarantee the performance of the proposed technique in achieving the best possible optimization result. Thus, various related objective functions were identified from earlier researchers recognized as the minimum total cost need by the generating units, less emission quantities to ensure a clean environment and the smallest system losses and certain constraints that must be satisfied as well during the network operations in EELD solutions (Mishra, 2005). In addition, the multi objective functions also examined by a combination several single objective functions into a multi objective functions formula known as a weighted sum method that is the advance of traditional method to address mutual incompatible objective functions solution (Brar et al., 2006). Thoroughly, the original Meta-EP and AIS strategies had been conducted and compared with the NMEP solution for single and multi-objective functions. The best solution is based on the lowest total cost, minimum in emission quantities and smallest system losses as respect to the particular objective solution while the fitness of multi objective functions is nearer to 1 as the finest result of the respective multi-objective solutions.

1.2 Problem Statements

The economic dispatch problem is one important issue that raises an attention among electric utilities and consumers nowadays. In consequence, the quality load demand is in a critical situation as the capacities is increasing and required more power plants in a power system generation to meet the consumer load demand (Zhang and Tolbert, 2005). Furthermore, the sufficient load demand with secured of power system operation is necessary to prevent the power system failure caused by an extreme load demand increases without a secured of power system operation (Nikolakakis et al., 2017).

Generally, the main issue in the EELD problem is addressed to minimize the total generation cost among generating units in the power system networks. Though, a few recent researchers stated that the complete cost not more applicable alone, as according to the world environmental concern (Kalil et al., 2006). For that reason, the total emission and system losses must also consider as types of objective functions that caused by operation of generator fuel burning. Based upon that, the reduction in the quantities of emission dispersed during power system generation, gained will respond to the government that declare for the clean air act of 1990 (Sharifi et al., 2017). Thus, each particular committed generating unit seeks to deliver the sufficient load demands without ignoring the emission issue together with the optimal cost and losses. Due to the large and complexity of power system solution made the security criteria as a compulsory aspect to be highlighted therefore the limitation for equality and inequality constraints parameters were specified (Hemamalini and Simon, 2008).

In addition, most researchers claimed that, EELD problem must also look at the influence between all the identified singular objective functions simultaneously or well known as multi objective functions. This functions is formed by combining two or more the single objective functions using the common weighted sum method (Alli et al., 2017). Moreover, this multi objective approach has been verified as a faster simulation solution than single objective approach in producing precision EELD problems (Rughooputh and King, 2003).

The traditional methods have some disadvantages in practical system since the solution involved with the non-linear complexity, non-convex and non-continuous problems and higher operation cost. Then, the modern methods have been introduced to fix the weaknesses of the traditional method. However, the modern methods have a several limitations in order to generate the solution. Thus, the hybrid methods solution is proposed to rehabilitate the previous weakness along with improved the existing method. Besides, the selected advantages of two modern methods are merged together in order to construct the hybrid method is the fundamental the hybrid methods provide the best solution for EELD problems. Additionally, the advantages of hybrid method are able to solving the EELD problems not only on single objective but also in the multi objective functions.

All the highlighted problem statements were simplified as the following:

1. The public concerns over the cost of electricity together with environmental friendly obtained the research purpose. Consequently, the minimum total cost, the smallest total emission and less system losses were identified as the most important significant objective functions in EELD power system solution (Zou et al., 2017).
2. While, the EELD also heading to unsuccessful solution when the total load demand increasing without security monitoring. For that reason, the limitation of equality and inequality parameters must be specified and include along with the objective functions to optimize (Sharifzadeh et al., 2017).
3. Moreover, the problems faced by the classical method such as limitation issues for generate the result, required more time to completing the task and unsuitable to solving complicated solution that required for an improvement new technique to fill the gap based on the current techniques which advance in solving the non-linear, non-continuous and non-convex EELD problems (Mahdi et al., 2017).
4. A single objective solutions alone were no longer suitable since only provide the finest solution for individual objective functions respectively. However, the influence of the overall objective functions to EELD problems is more significant by applying the multi objective functions with security criteria during the optimization method implementation (Zhang et al., 2017).
5. Various hybrid techniques were introduced as the enhancement to the existing modern heuristic methods in solving the optimization problems. Those hybrid approaches were formed by integrating whether between the modern heuristic techniques or with traditional techniques. The integration complements those selected techniques and indirectly overcome the weaknesses arise in the original